UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF NEW YORK

L.T AND M.T. by their parent Jeffrey N. Thomas, JEFFREY N. THOMAS as parent of L.T and M.T.; T.L., B.L., R.L., A.L. by their parent Karen LeClair; KAREN LECLAIR as parent of T.L., B.L., R.L., A.L.; J.S. by his parent Danielle Schipano; DANIELLE SCHIPANO as parent of J.S.; B.P by his parent Andrea Penamora, ANDREA PENAMORA as parent of B.P.; E.W. by her parent Joseph Whitehead; and JOSEPH WHITEHEAD as parent of E.W. Plaintiffs, vs. HOWARD A. ZUCKER, in his official capacity and in his individual capacity, Defendant.	Civil Action No.: 1:21-cv-1034 (LEK/DJS) **Declaration of Jayanta Bhattacharya**

Declaration of Jayanta Bhattacharya

Jay Bhattacharya, M.D., Ph.D., pursuant to 28 U.S.C. §1746, declares that:

1. I am a Professor of Medicine at Stanford University and have been on the Stanford University faculty since 2001. I have firsthand personal knowledge of the facts set forth below and could competently testify about them if called as a witness.
2. Based on my education, training, experience, and ongoing review of the academic literature in the context of COVID-19, it is my professional opinion that mask mandates

in schools are unnecessary to control mortality and severe disease from COVID-19 disease. There is no high-quality evidence supporting the proposition that requiring children to wear masks in schools is effective in slowing the community spread of the SARS-CoV-2 virus, which causes COVID-19. My work in this case is on a pro-bono basis, as I have accepted no personal payments for any work that I have conducted during the epidemic.

Professional Background

3. I have an M.D. and a Ph.D. in economics, both earned from Stanford University. I am the director of the Stanford Center for Demography and Economics of Health and Aging. At Stanford, I teach courses on health economics in the Economics Department and on advanced statistical methods in the School of Medicine. I am also a research associate at the National Bureau of Economic Research.
4. My primary research area is health economics, which includes a focus on epidemiology and infectious disease epidemiology. Between 1996 and 2021, I have published 154 articles in peer-reviewed journals, including top-ranked peer-reviewed journals in economics, statistics, public health, epidemiology, medicine, and health policy literatures.
5. I have published numerous peer-reviewed papers on the economics and medicine of infectious disease, including on the economics and epidemiology of HIV, H1N1 flu, H5N1 flu, seasonal influenza, antimicrobial resistance and antibiotic use, and COVID-19.
6. I have written a popular textbook, *Health Economics*, used to teach the subject in universities worldwide. The textbook includes a chapter on economic epidemiology that surveys the literature on disease modeling, including compartment models such as the

Susceptible-Infected-Recovered (SIR) models, commonly used to forecast the COVID-19 epidemic.

7. I have been actively researching the COVID-19 epidemic using my expertise in infectious disease epidemiology and health economics. To date, I have published six papers in peer-reviewed journals related to the epidemic, and I have published multiple editorials, including on economic, epidemiological, public health issues related to the epidemic. In particular, I published two popular piece in the Wall Street Journal and the Orange County Register on the wisdom mandating masks on children.

8. My published papers on COVID-19 include the first published serological study measuring the prevalence of the COVID-19 epidemic. This study, conducted in Los Angeles County ("L.A. County"), uses evidence from a specific antibody response to SARS-CoV-2 (the virus that causes COVID-19) infection in an adult community-dwelling sample picked to be representative of the county. This piece was published in the Journal of the American Medical Association, one of the leading peer-reviewed journals in medicine. This paper finds that by April 10-11, 2020, 4.3% of L.A. County adults show specific antibody evidence of prior or current COVID-19 infection. This prevalence rate represents a multiple of 43.5 times the number of cases confirmed by the county public health authority by that date. One important implication of this paper is that the infection fatality rate from COVID-19 in L.A. County up to the date of the survey (that is, the probability of dying from a SARS-CoV-2 infection) is at least an order of magnitude lower than the case fatality rate. The case fatality rate includes only patients infected with SARS-CoV-2 and identified as a case in the denominator of the calculation. Cases most typically include patients who have severe symptoms and thus come to the

attention of medical authorities. Our study shows that cases represented only a small fraction of the set of people who have been infected with SARS-CoV-2 even early in the epidemic. I served as the senior author for this article.

9. I am also the senior author of the Santa Clara County ("SCC") seroprevalence study. It is the first seroprevalence study where the study team made a scientific paper available, and it is still, to my knowledge, among the largest community seroprevalence surveys in the U.S. The results from the SCC study were similar to the results from the L.A. County seroprevalence study. On April 3rd & 4th, 2020, the seroprevalence of SARS-CoV-2 antibodies in the SCC sample, reweighted to match the zip code of residence, sex, and race distribution of SCC, was 2.8%. The SCC study has been enormously influential and has served as a template for the many seroprevalence studies that have followed it. The SCC study is now published in the peer-reviewed International Journal of Epidemiology and has generated over 550 citations (according to Google Scholar accessed on August 6, 2021) to date.

10. In addition to these seroprevalence studies, I published a peer-reviewed paper in the *Journal of Public Health* on racial disparities in knowledge and attitudes early in the epidemic regarding the danger posed by COVID-19 infection and the efficacy of personal behaviors like hand washing and social distancing in protecting against infection. I am an author of a paper titled "Visualizing the Invisible: The Effect of Asymptomatic Transmission on the Outbreak Dynamics of Covid-19." published in Computer Methods in Applied Mechanics and Engineering. This paper presents the first forecasting model that accounts for data provided by seroprevalence studies such as the L.A. County and SCC studies. In particular, the model accounts for the vast population of previously

infected people identified by the seroprevalence studies and challenges the notion that contact tracing can be a viable strategy to control the further spread of COVID-19 infection.

11. Finally, I published a peer-reviewed paper in the *European Journal of Clinical Investigation* entitled "Assessing Mandatory Stay-at-Home and Business Closure Effects on the Spread of COVID-19." This paper developed statistical evidence from the experience of multiple countries to measure the contribution of mandatory stay-at-home orders (lockdowns) and business closures on the spread of the SARS-CoV-2 virus in the initial months of the epidemic. Our primary finding is that countries that adopted mandatory stay-at-home orders or business closures were statistically indistinguishable from countries that did not (notably Sweden and South Korea) in terms of the spread of the virus in the population.

12. In addition to my published work, I have been invited to serve as a peer reviewer for many scientific journals to review COVID-19 related submissions by other scientists. These journals include the British Medical Journal, Health Affairs, the Journal of Infectious Disease, the Annals of Internal Medicine, and several other prominent journals. For these journals, I have provided scientific advice regarding the publication of articles on topics related to the COVID-19 epidemic.

13. I have been invited to testify several times in the U.S. Congress, state legislatures, and the Florida governor regarding various aspects of the science and policy regarding COVID-19, including two such occasions when I provided testimony on school mask mandates. I have also provided expert affidavits and sworn testimony pro bono in multiple court challenges to various lockdown policies in Florida, California, Maryland, and Michigan,

as well as in Quebec, Alberta, and Manitoba, Canada. Among the cases I have advised include three religious liberty cases that have reached the U.S. Supreme Court and two cases involving the provision of in-person schooling (one in Florida and one in California).

14. Most relevant to this case, in September 2020, I participated in an invited live roundtable discussion led by Florida Governor Ron DeSantis on the evidence regarding the safety of reopening Florida and the health harms from continued lockdown. My testimony presented the scientific evidence on the infection fatality rate from COVID-19 infection by age, the collateral damage from lockdowns on physical and psychological health, and on the safety of opening schools for in-person instruction. In March 2021, I participated in another public roundtable discussion with Gov. DeSantis focused on the wisdom of requiring schoolchildren to wear masks in school. I published a summary of the testimony I provided – in which I concluded that the harms of masking children outweigh benefits – in a Wall Street Journal piece.
15. Attached hereto as **Exhibit A** is a true and accurate copy of my *Curriculum Vitae*.

COVID-19 Infection Fatality & Other Risks

16. SARS-CoV-2, the virus that causes COVID-19 infection, entered human circulation some time in 2019 in China. The virus itself is a member of the coronavirus family of viruses, several of which cause typically mild respiratory symptoms upon infection. The SARS-CoV-2 virus, by contrast, induces a wide range of clinical responses upon infection. These presentations range from entirely asymptomatic infection to mild upper respiratory disease

with unusual symptoms like loss of sense of taste and smell, hypoxia, or a deadly viral pneumonia that is the primary cause of death due to SARS-CoV-2 infection.

17. The mortality danger from COVID-19 infection varies substantially by age and a few chronic disease indicators.[1] For a majority of the population, including the vast majority of children and young adults, COVID-19 infection poses less of a mortality risk than seasonal influenza. By contrast, for older populations – especially those with severe comorbid chronic conditions – COVID-19 infection poses a high risk of mortality, on the order of a 5% infection fatality rate.

18. The best evidence on the infection fatality rate from SARS-CoV-12 infection (that is, the fraction of infected people who die due to the infection) comes from seroprevalence studies. The definition of seroprevalence of COVID-19 is the fraction of people in a population who have specific antibodies against SARS-CoV-2 in their bloodstream. A seroprevalence study measures the fraction of a population who have antibodies that are produced specifically by people infected by the SARS-CoV-2 virus. The presence of specific antibodies in blood provides excellent evidence that an individual was previously infected.

19. Seroprevalence studies provide better evidence on the total number of people who have been infected than do case reports or positive reverse transcriptase-polymerase chain reaction (RT-PCR) test counts. PCR tests are the most common type of test used to check whether a person currently has the virus or viral fragments in their body (typically in the nasopharynx). The PCR test should not be used to count the total number of people who

[1] Public Health England (2020) Disparities in the Risk and Outcomes of COVID-19. August 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/908434/Disparities_in_the_risk_and_outcomes_of_COVID_August_2020_update.pdf

have been infected to date in a population. Case reports and PCR test counts both miss infected people who are not identified by the public health authorities or who do not volunteer for RT-PCR testing. That is, they miss people who were infected but recovered from the condition without coming to the attention of public health authorities. Because they ignore unreported, fatality rate estimates based on case reports or positive test counts are substantially biased toward reporting a higher fatality rate.

20. The CDC estimates that the infection fatality rate for people ages 0-19 years is 0.003%, meaning infected children have a 99.997% survivability rate. The CDC's best estimate of the infection fatality rate for people ages 20-49 years is 0.02%, meaning that young adults have a 99.98% survivability rate. The CDC's best estimate of the infection fatality rate for people age 50-69 years is 0.5%, meaning this age group has a 99.5% survivability rate. The CDC's best estimate of infection fatality rate for people ages 70+ years is 5.4%, meaning seniors have a 94.6% survivability rate.

21. A study of the seroprevalence of COVID-19 in Geneva, Switzerland (published in *The Lancet*)[2] provides a detailed age breakdown of the infection survival rate in a preprint companion paper[3] 99.9984% for patients 5 to 9 years old; 99.99968% for patients 10 to 19 years old; 99.991% for patients 20 to 49 years old; 99.86% for patients 50 to 64 years old; and 94.6% for patients above 65.

22. The COVID-19 vaccines approved for use in the U.S. are very effective in substantially reducing the infection fatality rate. According to the US Centers for Disease Control, the mRNA vaccines were 94% effective against COVID-19 hospitalization for patients 65 and

[2] Silvia Stringhini, et al., *Seroprevalence of Anti-SARS-CoV-2 lgG Antibodies in Geneva, Switzerland (SEROCoV-POP): A Population Based Study* (June 11,2020) THE LANCET, https://bit.ly/3187S13.
[3] Francisco Perez-Saez, et al. *Serology- Informed Estimates of SARS-COV-2 Infection Fatality Risk in Geneva, Switzerland* (June 15,2020) OSF PREPRINTS, http://osf.io/wdbpe/.

older.[4] In a study of the effectiveness of the vaccine of frontline workers in real-world settings, the mRNA vaccines reduced COVID-19 infections by 90%.[5] So infection fatality rates that I provide above are overestimated by at least one order of magnitude. Fully vaccinated, non-elderly teachers in classrooms face a vanishingly small risk of mortality even if the SARS-CoV-2 virus infects them.

23. COVID-19 is not a serious threat to schoolchildren, especially younger children—even if they contract the disease.[6] To begin, COVID-19 is almost never fatal for schoolchildren, as I have shown above. According to a Bravata et al., 2021 "[t]he CDC estimates that compared to adults 40 to 49 years of age, children 5 to 17 years of age have 160 times lower risk of death from COVID-19 and 27 times lower risk of hospitalization from COVID-19."[7] Fewer than 350 children "under 18 have died with a Covid diagnosis code in their record."[8]

24. Indeed, data from the UK regarding fatality rates from the Delta variant show the case fatality rate from Delta is lower than other variants, and it is near 0.0% for those under fifty years old.[9] Given the death rate from COVID-19 is positively related to age, and the data

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[4] Tenforde MW, Olson SM, Self WH, et al. Effectiveness of Pfizer-BioNTech and Moderna Vaccines Against COVID-19 Among Hospitalized Adults Aged ≥65 Years — United States, January–March 2021. MMWR Morb Mortal Wkly Rep 2021;70:674–679. DOI: http://dx.doi.org/10.15585/mmwr.mm7018e1external icon

[5] Thompson MG, Burgess JL, Naleway AL, et al. Interim Estimates of Vaccine Effectiveness of BNT162b2 and mRNA-1273 COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential and Frontline Workers — Eight U.S. Locations, December 2020–March 2021. MMWR Morb Mortal Wkly Rep 2021;70:495–500. DOI: http://dx.doi.org/10.15585/mmwr.mm7013e3external icon

[6] Especially children without preexisting conditions—"[i]t appears that children who become severely ill with acute Covid-19 often have one or more underlying conditions, including medical complexity, obesity, asthma, sickle cell disease, and immunosuppression." Jessica H. Rubens et al., *Acute COVID-19 and Multisystem Inflammatory Syndrome in Children*, BMJ: CLINICAL UPDATES, Mar. 1, 2021, at 2.

[7] Dena Bravata, et al. *Back to School: The Effect of School Visits During COVID-19 on COVID-19 Transmission* 9 (Nat'l Bureau of Econ. Research, Working Paper No. 28645, Apr. 2021).

[8] Marty Makary, Opinion, *The Flimsy Evidence Behind the CDC's Push to Vaccinate Children*, WALL ST. J. (July 19, 2021), https://on.wsj.com/2VYqit1.

[9] *See* Public Health England (2021) SARS-CoV-2 variants of concern and variants under investigation in England. Technical Briefiing 20. August 6, 2021. (showing that only 48 of the 147,612 unvaccinated people under 50 who

from the U.K. indicate that relationship still holds, the U.K. data suggest the Delta variant is *not* more lethal to schoolchildren than, for instance, seasonal influenza infection.

25. The incidence of school-age children requiring hospitalizations due to COVID-19 are also rare. As even those who advocate for stricter non-pharmaceutical interventions in school settings acknowledge, COVID-19 "infection in children is generally characterized by mild illness.[10] Only a minority of children require hospitalization … ." The public health agency in the Netherlands similarly concludes "Worldwide, relatively few children have been reported with COVID-19. . . Children become less seriously ill and almost never need to be hospitalized because of" COVID-19."[11]

26. Experience over the last year and a half bears this out. For example, in Sweden, "[f]rom March through June 2020, a total of 15 children with Covid-19 were admitted to an ICU (0.77 per 100,000 children in this age group)."[12]

27. There is a spike in hospitalizations that correspond to the prevalence of the Delta variant—but even that is low, approximately 0.4 per 100,000, and roughly corresponds to the last peak in admissions. In any event, it still a small percentage of all hospital admissions. This suggests the Delta variant is no worse for children than prior variants. Data from across

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were infected with the Delta variant died, or 0.03%).
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009243/Technical_Briefing_20.pdf.

[10] Zoe Hyde, Perspective, *COVID-19, Children and Schools: Overlooked and at Risk*, 213 MED. J. AUSTL. 444, 444 (2020)

[11] *See Children, School and COVID-19*, NAT'L INST. PUB. HEALTH & ENV'T (last updated July 14, 2021), https://www.rivm.nl/en/coronavirus-Covid-19/children-and-Covid-19).

[12] Jonas F. Ludvigsson, Letter to the Editor, *Open Schools, Covid-19, and Child and Teacher Morbidity in Sweden*, 384 NEW ENG. J. MED. 669, 669 (2021)

the country confirms that conclusion, with the weekly rate of admission for those under 18 years old much lower than for those over 18.[13]

28. The UK has seen the same pattern, with hospital admission rates for school-age children near their prior peak for each age cohort, though still much smaller compared to other age cohorts[14]. Two possible explanations for this include age prioritization of vaccination—which prioritized older individuals and hence protected them differentially— and a surge in Respiratory Syncytial Virus (RSV) infection which does pose moderate danger for children, rather than increasing virulence of the delta variant against children.

29. In addition to hospitalizations, severe health complications from COVID-19 are also rare. Long-lasting symptoms that persist after recovery from COVID-19 infections ("long COVID") and Multisystem Inflammatory Syndrome (MIS-C) are also rare among children. As to the latter, "a small fraction of children can experience a severe post-infectious multisystem inflammatory syndrome."[15] Consider the U.S. In total, there have been 4,404 cases of MIS-C in children between the ages of 0 and 20 in the country since mid-May 2020.[16] That is roughly 0.1% of cases in children in that age group.[17] Rubens et al. confirm that MIS-C is rare: "Overall, MIS-C is a rare complication of SARS-CoV-2. A May 2020 systematic review from 26 countries reported a MIS-C incidence of 0.14% among all

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[13] *COVID Data Tracker*, CDC (last visited Aug. 14, 2021), https://Covid.cdc.gov/Covid-data-tracker/#Covidnet-hospitalization-network.

[14] *See Coronavirus (COVID-19) Latest Insights: Hospitals*, OFF. NAT'L STAT. (Aug. 13, 2021), https://bit.ly/3ALzikG.

[15] Hyde, *supra*, at 444; *see also* Ludvigsson, *Open Schools*, *supra*, at 669 ("[A] total of 15 children [between the ages of 1 and 16] with Covid-19 (*including those with MIS-C*) were admitted to an ICU (0.77 per 100,000 children in this age group).") (emphasis added).

[16] *Multisystem Inflammatory Syndrome*, CDC (last updated July 30, 2021), https://bit.ly/3xMxdTC.

[17] For data for total COVID-19 cases broken out by age, see *Demographic Trends of COVID-19 Cases and Deaths in the US Reported to CDC*, CDC (last updated Aug. 14, 2021), https://bit.ly/3iPfCpW. The number is a rough approximation due to the difference in reporting periods and because the CDC's age breakdown does not allow for totaling of cases in people aged 0 to 20. To approximate this number, the analysis totals cases for people aged 0 to 17, which would tend to increase the percentage presenting with MIS-C.

children with SARS-CoV-2 infection, but this estimated incidence may be imprecise because of potential underestimation of overall SARS-CoV-2 infections in children."[18]

30. As for long COVID, the evidence "suggests a very low prevalence of [it]" in children.[19] Indeed, "[s]eropositive children, all with a history of pauci-symptomatic SARS-CoV-2 infection, did not report long COVID more frequently than seronegative children."[20] Another study found that symptomatic COVID-19 infection in schoolchildren (5 to 17 years old) "is usually of short duration (6 days vs. 11 days in adults), with low symptom burden."[21] Further, the authors note that "[o]nly a small proportion of children had illness duration beyond 4 weeks, and their symptom burden decreased over time. Almost all children had symptom resolution by 8 weeks."[22] This is consistent with studies showing that long COVID is rare among the general population. [23]

31. The most reliable study was recently published by the Office of National Statistics in the U.K.[24] It is the most reliable study because of its large sample size and, notably, a control group of children who had no history of COVID-19 infection. Strikingly, among children

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[18] Jessica H. Rubens et al., *Acute COVID-19 and Multisystem Inflammatory Syndrome in Children*, BMJ: CLINICAL UPDATES, Mar. 1, 2021, at 3

[19] Thomas Radtke et al., *Long-Term Symptoms After SARS-CoV-2 Infection in School Children: Population-Based Cohort with 6-Months Follow-Up* 6 (MedRxiv, Preprint, May 18, 2021)

[20] *Id.* at 6.

[21] Erika Molteni et al., *Illness Duration and Symptom Profile in Symptomatic UK School-Aged Children Tested for SARS-CoV-2*, LANCET ADOLESCENT HEALTH, Aug. 3, 2021, at 7.

[22] *Id.* at 2.

[23] *See* Alex J. Walker, *Clinical Coding of Long COVID in English Primary Care: A Federated Analysis of 58 Million Patient Records* In Situ *Using OpenSAFELY*, BRIT. J. GEN. PRAC., 2021, at 3 ("Up to 25 April 2021, there were 23,273 (*0.04%*) patients with a recorded code indicative of a long-COVID diagnosis.") (emphasis added).

[24] Office of National Statistics, UK. Technical article: Updated estimates of the prevalence of post-acute symptoms among people with coronavirus (COVID-19) in the UK: 26 April 2020 to 1 August 2021. https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/articles/technicalarticleupdatedestimatesoftheprevalenceofpostacutesymptomsamongpeoplewithcoronaviruscovid19intheuk/26april2020to1august2021

age 2 – 11 years, the children in the control group (who had never previously had COVID) had a higher rate of "long-COVID" symptoms (4.1%) than the kids who had previously had COVID (3.2%) four months after recovery from infection. Among children 12-16, the rates of long-COVID symptoms at four months were similar and low in the control (1.3%) and COVID-recovered groups (3.0%). Among young adults age 17-24, the rates of "long-COVID" were identical in the control and COVID-recovered groups (3.6%).

32. To be sure, there is a chance that COVID-19 results in serious, negative outcomes among children—as there is with any disease. But the evidence, thankfully, shows children who are infected with COVID-19 are overwhelmingly likely to recover fully with only mild illness and no lingering effects.

Children are Inefficient Transmitters of the Virus

33. Even without masks, the overwhelming weight of scientific data suggests that the risk of transmission of the virus from children aged six and below to older people is negligible and from children between 7 and 12 to older people is small relative to the risk of transmission from people older than 18 to others.

34. The most important evidence on childhood spread of the disease comes from a study conducted in Iceland and published in the New England Journal of Medicine[25]. The data for this study come from Iceland's systematic screening of its population to check for the virus. This is the most important study on this topic because it is the only study that definitively establishes the direction of the spread of the virus from contact to contact. The study reports on a population-representative sample and a sample of people who were

[25] Daniel F. Gudbjartsson, Ph.D., Agnar Helgason, Ph.D., et al., *Spread of SARS-CoV-2 in the Icelandic Population,* The New England Journal of Medicine, https://www.nejm.org/doi/full/10.1056/NEJMoa2006100 (June 11, 2020).

tested because of the presence of symptoms consistent with COVID-19 infection. The study team isolated SARS-CoV-2 virus samples from every positive case, sequenced the virus's genome for every patient, and tracked the mutation patterns in the virus. This analysis, along with contact tracing data, allowed the study team to identify definitively who passed the virus to whom. There have been hundreds of minor mutations of the virus identified, which typically do not alter the function of the virus much, but which provide a unique fingerprint, of sorts, that makes it possible to tell whether two patients could possibly have passed the virus to one another. From this analysis, the senior author of the study, Dr. Kari Stefansson, concluded[26] that "[E]ven if children do get infected, they are less likely to transmit the disease to others than adults. We have not found a single instance of a child infecting parents. There is amazing diversity in the way in which we react to the virus."

35. Though the Iceland study is the only definitive study, there are a number of other studies that use contact tracing methods to investigate the role of children in disease spread. The bulk of such studies conclude that children play a small role, consistent with the Iceland data.

36. A French study[27], conducted by scientists at the L'Institut Pasteur, examined data from late April 2020 on schoolteachers, students, and their parents in Crepy-en-Valois in France. The schools in France were closed from the end of January on, at first because of the February holiday and then the late February lockdown. During this period, French schools

[26] Roger Highfield, *Coronavirus: Hunting Down COVID-10*, Science Museum Group, https://www.sciencemuseumgroup.org.uk/blog/hunting-down-Covid-19/ (April 27, 2020).
[27] Arnaud Fontanet, MD, DrPH, Rebecca Grant, et al., *SARS-CoV-2 Infection in Primary Schools in Northern France: A Retrospective Cohort Study in an Area of High Transmission,* Institut Pasteur, https://www.pasteur.fr/fr/file/35404/download (last visited July 9, 2020).

implemented no restrictions on students – neither social distancing nor mask requirements. The authors found three cases among kids in January using antibody tests but found no evidence of virus spread to other kids or teachers from those early cases. Any spread between the end of January and April (when the authors collected samples) must have occurred during the lockdown. The authors' main conclusion[28] from these facts is that parents were the source of infections in school children; children were not the source. Those kids who tested antibody positive at the end of April, because of the circumstances of the lockdown, must have become positive from a source other than their school. The primary contacts of the young children were their parents, of whom 61% were positive, which is consistent with parent-to-child spread. This is also consistent with the results showing that only 6.9% of parents tested positive for the virus among antibody-negative kids in April. The authors' main conclusion mirrors the one reached in the Icelandic study showing that the disease spreads less easily from children to adults than from adults to adults, *even in the absence of masking requirements*.

37. Researchers in Ireland conducted a similar study[29] which analyzed 1,160 children and adults in Ireland who were physically present in a school at some time between March 1st and March 13th, where a COVID-19 case was identified. (Schools were closed in Ireland on March 12th). The authors found three children (between 10 and 15 years old) and three adults with COVID-19 infections. Their study followed students and families after the school closures to see if there was any evidence of disease spread from these identified

[28] *COVID-19 In Primary Schools: No Significant Transmission among Children or From Students to Teachers,* Institut Pasteur, https://www.pasteur.fr/en/press-area/press-documents/covid-19-primary-schools-no-significant-transmission-among-children-students-teachers (June 23, 2020).
[29] Laura Heavey, Geraldine Casey, et al., *No Evidence of Secondary Transmission of COVID-19 from Children Attending School in Ireland, 2020,* Eurosurveillance, https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.21.2000903#html_fulltext (May 28, 2020).

cases. While the study authors mention physical distancing, hand hygiene, and cough etiquette as interventions implemented in Irish schools at the time, they do not mention required masking. All six patients had PCR confirmed COVID-19 disease but contracted the virus from contacts outside of school. Despite identifying 722 contacts, the study authors reported finding no instance of an infected child infecting another child. The infected adults, by contrast, had many fewer contacts – 102 – but did pass on the infection to a few adult contacts. This, even though the infected children engaged in "music lessons (woodwind instruments) and choir practice, both of which are reportedly high-risk activities for transmission." *Ibid.* As with the French study mentioned above, the Irish schools did not mandate masking at the time of the study, and they still do not require them for children under 13.[30]

38. Based on contact tracing data, a report[31] by the ministry of health in the Netherlands finds almost no disease spread by infected patients 20 and under at all, and only limited spread by adults 20-25 to others outside their own age category. The authors of the study concluded: "Data from the Netherlands also confirms the current understanding: that children play a minor role in the spread of the novel coronavirus. The virus is mainly spread between adults and from adult family members to children. The spread of COVID-19 among children or from children to adults is less common." Hygiene standards in the Netherlands promulgated by its National Institute for Public Health and the Environment make no recommendation of masking for either primary school or secondary school

[30] Citizens Information Ireland. Face Coverings During COVID-19. https://www.citizensinformation.ie/en/health/covid19/face_coverings_during_covid19.html# (Sept. 25, 2021)

[31] *Children and COVID-19*, National Institute for Public Health and the Environment, https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19 (July 2, 2020).

students.[32]

39. A German[33] study reports a strikingly similar finding on the likelihood of pediatric disease spread. The German Society for Pediatric Infectious Diseases collected data on all children and adolescents admitted to a hospital for COVID-19 treatment between mid-March and early May 2020 – 128 patients were admitted to 66 different hospitals. The authors sourced the infection for 38% of these patients, which turned out to be a parent 85% of the time. Though the authors document a limitation of small sample size, they conclude that "In contrast to other epidemic viral respiratory infections, the primary source of infection with SARS-CoV-2 appears not to be other children." The authors reported a single death among these 128 pediatric patients.

40. A study of 23 family disease clusters in Greece, published on August 7, 2020, in the *Journal of Medical Virology*, found that in 91% of the clusters, an adult was the first person to be infected. Their contact tracing effort attempted to clarify the direction of disease spread by careful questioning about the relative timing of the development of symptoms. They found no evidence of either child to adult spread or even child to child spread. They concluded that "[w]hile children become infected by SARS-CoV-2, they do not appear to transmit the virus to others. Furthermore, children more frequently have an asymptomatic or mild course compared to adults."[34]

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[32] Hygiene Guideline for Primary Schools, National Institute for Public Health and the Environment. https://www.rivm.nl/hygienerichtlijnen/basisscholen (September 25, 2021); and General Hygiene Guideline. National Institute for Public Health and the Environment. https://www.rivm.nl/hygienerichtlijnen/algemeen (Sept. 25, 2021).

[33] Armann, J. P., Diffloth, N., Simon, A., Doenhardt, M., Hufnagel, M., Trotter, A., Schneider, D., Hübner, J., & Berner, R. (2020). Hospital Admission in Children and Adolescents With COVID-19. Deutsches Arzteblatt international, 117(21), 373–374. https://doi.org/10.3238/arztebl.2020.0373

[34] Helena C. Maltezou Rengina Vorou Kalliopi Papadima, et al. (2020) "Transmission dynamics of SARS-CoV-2 within families with children in Greece: a study of 23 clusters" Journal of Medical Virology, https://doi.org/10.1002/jmv.26394 (accessed August 12, 2020).

41. A study by the Federal Office of Public Health of Switzerland analyzed 793 cases reported by Swiss doctors in late July 2020.[35] The reports included the place where each patient most likely contracted the infection. The most common source of infection was at home, with 27.2% tracing their disease there. School, by contrast, consisted of only 0.3% of the infections; exactly two of the 793 cases could be tracked to a school. This study has some limitations: first, it is a contact tracing study without genetic sequencing verification, so it is impossible to judge the direction of diseases spread with certainty (i.e., from adult to child or child to adult). Second, the report provides no details about the age of the cases, so it is not possible to separately glean the disease acquisition frequencies for children and adults; and third, only summer schools were in session during this period. Nevertheless, the results strongly suggest that schools are a minor source of community spread of the infection.

42. A large study of 1,900 children attending an urban summer school in Barcelona, Spain, found only 39 new index cases (30 pediatric) over five weeks.[36] (An index case is an initial person identified by a positive test for the virus, from whom close contacts are identified). The investigators chose this setting because they viewed it as a model for what to expect from school openings in the fall. Those 39 index cases interacted with another 253 children within their "cohabitation groups," of whom only 12 developed an infection"– a secondary attack rate of 4.7%. The low secondary attack rate was similar for children of all ages attending the programs, ranging up to 17 years old. The report does not mention masks as

[35] Office fédéral de la santé publique OFSP (2020) “Rectificatif : les lieux de contamination sont les contextes familiaux et non les boîtes de nuit” Aug. 2, 2020. available at https://www.bag.admin.ch/bag/fr/home/das-bag/aktuell/news/news-02-08-2020.html

[36] Oriel Guell (2020) *Major coronavirus study in Spanish summer camps shows low transmission among children*. El Pais. (Aug. 26, 2020) available at https://english.elpais.com/society/2020-08-26/major-coronavirus-study-in-spanish-summer-camps-shows-low-transmission-among-children.html

a disease prevention method. Rather, the investigators attributed the success in controlling the spread of the disease to frequent handwashing by the children and organizing the children into "bubbles" so that the kids interacted with the same group of children all day long.

43. A comprehensive official report by Public Health England of the role of English schools, which were reopened on June 1, 2020, despite high community case numbers, in spreading the pandemic.[37] The author of this report found that cases and outbreaks were "uncommon across all educational settings" and that "[s]taff members had an increased risk of SARS-CoV-2 infections compared to students in any educational setting, and the majority of cases linked to outbreaks were in staff." In response to this study, U.K. education minister Gavin Williamson said: "The latest research, which is expected to be published later this year – one of the largest studies on the coronavirus in schools in the world – makes it clear there is little evidence that the virus is transmitted at school."[38]

44. Perhaps the best observational evidence (outside of the Iceland study) on the risk children pose to teachers comes from Sweden's COVID-19 policy. Swedish primary schools have been open for in-person instruction throughout the epidemic (high schools were closed briefly at the height of the epidemic), even when cases ran high in the community at large, with no masking required of its children.[39] In spring 2020, of the 1.8 million kids in school,

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[37] Sharif Ismail et al. (2020) "SARS-CoV-2 infection and transmission in educational settings: cross-sectional analysis of clusters and outbreaks in England" Public Health England, Aug. 12, 2020 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/911267/School_Outbreaks_Analysis.pdf

[38] Peter Walker (2020) "Little Evidence COVID Spreads in Schools, says Gavin Williamson" *The Guardian*, Aug. 10, 2020. https://www.theguardian.com/world/2020/aug/10/little-evidence-covid-spreads-in-schools-says-gavin-williamson

[39] Ludvigsson JF, Engerström L, Nordenhäll C, Larsson E. Open Schools, Covid-19, and Child and Teacher Morbidity in Sweden. N Engl J Med. 2021 Feb 18;384(7):669-671. doi: 10.1056/NEJMc2026670. Epub 2021 Jan 6. PMID: 33406327; PMCID: PMC7821981.

ages 1-15, zero died from COVID.[40] Furthermore, there is no evidence the teachers were at greater risk of COVID infections than others, despite their pupils not wearing masks. On the contrary, the rate of COVID-19 infection among teachers was lower than the average rate of COVID-19 infection among other Swedish essential workers. This result is confirmed by studies of the effect of school closures in the U.S. and elsewhere on overall excess mortality, which finds that school closures – much less mask mandates – on COVID risk were at best minimal.[41, 42]

45. The overwhelming bulk of scientific studies that have examined the topic – including the best studies, which take pains to distinguish correlation from causation – find that children play a limited role in spreading COVID-19 infection to adults. It is striking that this conclusion holds even in situations where children were not required to wear masks.

No Randomized Evidence of Efficacy of Masking in Limiting Disease Spread

46. There is by now a vast empirical literature purporting to evaluate the effectiveness of mask-wearing in limiting the spread of the SARS-CoV-2 virus. The question is complicated because it is unlikely that there is a single answer. The effectiveness of masks differ based on the type of mask (cloth vs. surgical vs. N95), protocols for replacing contaminated masks, how well trained the mask-wearer is in maintaining good mask fit, and a large number of other factors, including other non-pharmaceutical interventions such as hand washing, social distancing, and ventilation upgrades.

[40] Public Health Agency of Sweden (2020) "COVID-19 in Schoolchildren: A Comparison between Finland and Sweden" https://www.folkhalsomyndigheten.se/contentassets/c1b78bffbfde4a7899eb0d8ffdb57b09/covid-19-school-aged-children.pdf

[41] Dena Bravata, Jonathan H. Cantor, Neeraj Sood & Christopher M. Whaley (2021) Back to School: The Effect of School Visits During COVID-19 on COVID-19 Transmission. NBER Working Paper # 28645. April 2021. https://www.nber.org/papers/w28645 DOI 10.3386/w28645

[42] Walsh S, Chowdhury A, Braithwaite V, et alDo school closures and school reopenings affect community transmission of COVID-19? A systematic review of observational studiesBMJ Open 2021;11:e053371. doi: 10.1136/bmjopen-2021-053371

The effectiveness of masks in protecting the wearer against infection (self-protection) will also differ from the effectiveness of masks in protecting people near the wearer from becoming infected (source control). Studies conducted in laboratories on mannequins, for instance, are unlikely to translate well into real-world settings, where conditions differ sharply from the laboratory. Many ecological studies also estimate the correlation between the imposition of mask mandates and the subsequent spread of COVID-19 disease in various locations rather than at the individual level. However, it is notoriously difficult to adjust for bias caused by factors that researchers do not observe in such studies.

47. The best guide to the effectiveness of masks – the highest quality evidence – are randomized controlled trials that reduce bias from many sources on the effectiveness estimates. Though some have argued that randomized evaluations of the effectiveness of masking are impossible in the context of respiratory virus spread, there were more than a dozen randomized evaluations of masking in the context of the flu published before the pandemic in peer-reviewed journals. It has been more than 18 months since the beginning of the pandemic and the imposition of lockdown orders, and the efficacy of masking has been of intense policy interest. Nevertheless, there is to date only a single peer-reviewed randomized study published on the effectiveness of masks in self-protection against COVID-19. The study, which did not enroll children, found no statistically significant difference between the treatment group and control group regarding the probability of infection.[43]

48. Shockingly, there are no randomized evaluations of the effectiveness of masks on children in source control for COVID-19 (that is, the effectiveness of masks in protecting others in the context of schools or children). In the context of adults, there is a preprint (not yet peer-reviewed) randomized

[43] Bundgaard H, Bundgaard JS, Raaschou-Pedersen DET, von Buchwald C, Todsen T, Norsk JB, Pries-Heje MM, Vissing CR, Nielsen PB, Winsløw UC, Fogh K, Hasselbalch R, Kristensen JH, Ringgaard A, Porsborg Andersen M, Goecke NB, Trebbien R, Skovgaard K, Benfield T, Ullum H, Torp-Pedersen C, Iversen K. Effectiveness of Adding a Mask Recommendation to Other Public Health Measures to Prevent SARS-CoV-2 Infection in Danish Mask Wearers : A Randomized Controlled Trial. Ann Intern Med. 2021 Mar;174(3):335-343. doi: 10.7326/M20-6817. Epub 2020 Nov 18. PMID: 33205991; PMCID: PMC7707213.

study on the efficacy masking as source control. The study, conducted in Bangladesh, randomly assigned villages in that country to cloth masks, surgical masks, and control villages. In the villages chosen for masking, residents were offered masks for free, and various measures were implemented to encourage masking. Ultimately, about 40% of villagers in the villages chosen for masking wore masks, while about 10% wore masks in the control villages. Despite the sharp increase in masking, there was no statistically significant difference in the symptomatic seroprevalence of COVID-19 disease in the villages with cloth masks and the control villages. The villages assigned surgical masks had a slightly lower symptomatic seroprevalence rate than the control villages (0.76% vs. 0.69%), with a 95% statistical confidence bound that included zero effect and no measured difference in hospitalization or mortality. The study did not include children.

49. So in the context of COVID-19, there is no high-quality evidence supporting the notion that masks on children work to control disease spread, either self-protection or source control. By contrast, in the context of the flu, there is considerable randomized evidence that masks are not effective in reducing disease spread for both source control and self-protection.[44]

50. The literature on the efficacy of masks to control respiratory viruses is vast, so it is fortunate that four prominent groups have conducted comprehensive literature reviews. I will reproduce here the key conclusions conducted by teams of researchers at the Cochrane Collaborative, at the European CDC, at the Oxford University Centre for Evidence-Based Medicine, and at the US Centers for Disease Control. All of the reviews acknowledge the lack of randomized evidence in this area. Each differs in their conclusions about the effectiveness of masks, but those conclusions rest on the relative weight each research group put on randomized studies showing no benefit in masking versus poor quality correlational evidence that provided mixed results on mask effectiveness based on the setting.

[44] Jefferson T, Del Mar CB, Dooley L, Ferroni E, Al-Ansary LA, Bawazeer GA, van Driel ML, Jones MA, Thorning S, Beller EM, Clark J, Hoffmann TC, Glasziou PP, Conly JM. Physical interventions to interrupt or reduce the spread of respiratory viruses. Cochrane Database of Systematic Reviews 2020, Issue 11. Art. No.: CD006207. DOI: 10.1002/14651858.CD006207.pub5.

51. The Cochrane Collaborative is an organization of academics with a reputation for writing high-quality evidence summaries on a full range of important topics within medicine using a standardized approach to evidence evaluation. The Cochrane review of the mask literature separately evaluates the effectiveness of medical/surgical masks and N95 respirator masks.[45] Because there were no randomized studies in the context of COVID-19 when the study was published, the review focuses on the randomized studies in the influenza context. The authors conclude:

> "**Medical/Surgical Masks:** Seven studies took place in the community, and two studies in healthcare workers. Compared with wearing no mask, wearing a mask may make little to no difference in how many people caught a flu-like illness (9 studies; 3507 people); and probably makes no difference in how many people have flu confirmed by a laboratory test (6 studies; 3005 people). Unwanted effects were rarely reported, but included discomfort.
> **N95/P2 respirators:** Four studies were in healthcare workers, and one small study was in the community. Compared with wearing medical or surgical masks, wearing N95/P2 respirators probably makes little to no difference in how many people have confirmed flu (5 studies; 8407 people); and may make little to no difference in how many people catch a flu-like illness (5 studies; 8407 people) or respiratory illness (3 studies; 7799 people). Unwanted effects were not well reported; discomfort was mentioned."

52. In other words, according to a comprehensive evidence summary of mask effectiveness in the context of the flu – a virus that shares many physical properties with the SARS-CoV-2 virus and is transmitted similarly to SARS-CoV-2 – high-quality evidence finds no effect of masks on the spread of disease, even when the masks are employed by health care workers who are trained to use them properly.

53. The US CDC review, conducted last year, evaluates the randomized studies on the effectiveness of various personal protective measures, including face masks to protect against the spread of influenza.[46] The review's conclusion is straightforward:

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[45] *Ibid.*
[46] Xiao J, Shiu E, Gao H, et al. Nonpharmaceutical Measures for Pandemic Influenza in Nonhealthcare Settings—Personal Protective and Environmental Measures. Emerging Infectious Diseases. 2020;26(5):967-975. doi:10.3201/eid2605.190994.

> "In this review, we did not find evidence to support a protective effect of personal protective measures or environmental measures in reducing influenza transmission. Although these measures have mechanistic support based on our knowledge of how influenza is transmitted from person to person, randomized trials of hand hygiene and face masks have not demonstrated protection against laboratory-confirmed influenza, with one exception."

54. The one exception they note is a randomized study that found that regular hand washing may slow influenza spread in health care settings. The CDC review – conducted in mid-2020 – emphasizes the need for high-quality studies on masks and COVID-19. It is striking that there has only been two randomized evaluation published since this call for high-quality evidence last year (that is, the Danish and Bangladeshi mask studies I cite above) since the publication of this review by the CDC.

55. The review by the team at the Oxford University Centre for Evidence-Based Medicine – a group that (like the Cochrane Collaborative) is famous for its careful evidence summaries on a wide variety of health care topics – makes the same observations as the other groups.[47] Namely, they lament the lack of high-quality evidence evaluating the effectiveness of masks in the context of COVID-19. Unlike the other groups, the CEBM review documents several randomized studies in progress (including the Danish mask study referenced above). Though the CEBM study was published in July 2020, to my knowledge, none of these planned randomized studies have been completed or published beside the Danish and Bangladeshi mask studies referenced above.[48] The CEBM summary emphasizes the danger of making policy decisions (such as making masks mandatory) when the scientific evidence on the topic is so inadequate.

> "What do scientists do in the face of uncertainty on the value of global interventions? Usually, they seek an answer with adequately designed and swiftly implemented clinical studies as has been partly achieved with

[47] Tom Jefferson, Carl Heneghan (2020) Masking Lack of Evidence with Politics. Centre for Evidence Based Medicine working paper. Oxford University. https://www.cebm.net/covid-19/masking-lack-of-evidence-with-politics/

[48] During a person conversation on August 14, 2021, Prof. Carl Heneghan (Oxford University) confirmed to me that none of the planned randomized studies listed in the CEBM review (except for the Danish mask study cited here) had been completed, released as a working paper, or published to date.

> pharmaceuticals. We consider it is unwise to infer causation based on regional geographical observations as several proponents of masks have done. Spikes in cases can easily refute correlations, compliance with masks and other measures is often variable, and confounders cannot be accounted for in such observational research…The small number of trials and lateness in the pandemic cycle is unlikely to give us reasonably clear answers and guide decision-makers. This abandonment of the scientific modus operandi and lack of foresight has left the field wide open for the play of opinions, radical views, and political influence."

56. The literature review by the European CDC covers both the randomized evidence on masks and influenza spread that the other teams' review and the early observational evidence on masks and COVID-19.[49] The team evaluating this evidence places more weight on the low-quality observational studies than do some of the other teams. For this reason, I place less importance on the conclusions of this review than I do on the others. Still, they emphasize in their conclusions the need for more high-quality (i.e., randomized) evidence on the topic.

> "The evidence regarding the effectiveness of medical face masks for the prevention of COVID-19 in the community is compatible with a small to moderate protective effect, but there are still significant uncertainties about the size of this effect. Evidence for the effectiveness of non-medical face masks, face shields/visors and respirators in the community is scarce and of very low certainty. Additional high-quality studies are needed to assess the relevance of the use of medical face masks in the COVID-19 pandemic."

57. Since there is so little randomized data available to answer whether masks effectively protect the user or slow disease spread, it is natural to look to observational evidence. Observational data are most important when randomized evaluations are impossible for logistical or ethical reasons. However, this is not true for masks since there have been randomized studies on their effect on reducing transmission of respiratory viruses conducted – including one in the context of COVID-19. The problem with observational studies is that the adoption of a mask mandate (either in schools or in the community) is not a random decision and may be induced by the perceived threat of COVID cases near the time of adoption. Therefore, the correlation observed in observational

[49] European Centre for Disease Prevention and Control. Using face masks in the community: first update. 15 February 2021. ECDC: Stockholm; 2021.

data does not necessarily imply a causal relationship between a mask mandate and COVID outcomes.

58. That said, a comprehensive analysis of the correlation between COVID spread in the U.S. in the fall/winter wave of late 2020/early 2001, and the imposition of mask mandates found no correlation between them.[50] The authors of this peer-reviewed study concluded that "Earlier mask mandates were not associated with lower total cases or lower maximum growth rates. Growth rates and total growth were comparable between U.S. states in the first and last mask use quintiles during the Fall-Winter wave…We did not observe an association between mask mandates or use and reduced COVID-19 spread in U.S. states." If there is no correlation between mask mandates and COVID case growth, it seems unlikely that there is a causal relationship.

59. For mask mandates in schools, the observational evidence is mixed, with some studies finding correlations between mask requirements and cases and others finding no correlation.[51] No randomized studies have been conducted. Some studies given prominence by the CDC have been of particularly poor quality. For instance, the CDC cited one study conducted by Duke researchers in North Carolina as showing that masks on children reduced disease spread.[52] However, the study includes only 11 school districts that required masks and *no* control districts that did not require masks. Writing in the *Wall Street Journal* about the study, Duke University researcher Tom Nicholson wrote:

> In an inversion of logic, the report concluded that the only nonvariable in the data set [masks] must be the cause of low transmission rates in North Carolina schools. It should be obvious that proving some components of a strategy as useless doesn't demonstrate that others are effective. Such a claim requires a control group or appropriate statistical methods. The researchers might as well have attributed the low Covid rate in schools to

[50] Damian D.Guerra, Daniel J.Guerra. Mask mandate and use efficacy for COVID-19 containment in US States.International Research Journal of Public Health, 2021; 5:55. DOI: 10.28933/irjph-2021-08-1005

[51] Gettings J, Czarnik M, Morris E, et al. Mask Use and Ventilation Improvements to Reduce COVID-19 Incidence in Elementary Schools — Georgia, November 16–December 11, 2020. MMWR Morb Mortal Wkly Rep 2021;70:779–784. DOI: http://dx.doi.org/10.15585/mmwr.mm7021e1external icon

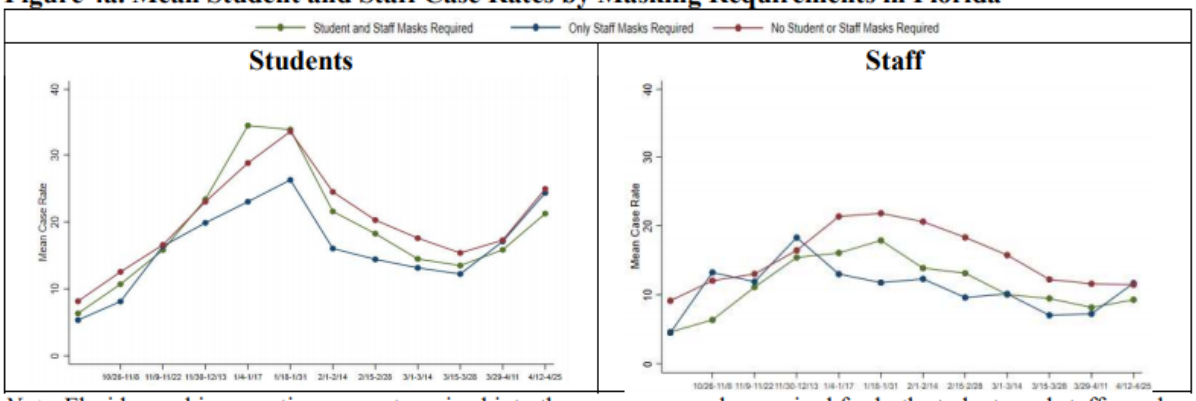
[52] US CDC. Science Brief: Transmission of SARS-CoV-2 in K-12 Schools and Early Care and Education Programs – Updated July 9, 2021. Accessed Sept. 25, 2021. https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/transmission_k_12_schools.html#in-person

wearing shoes.

60. One particularly notable observational study—notable for its detailed measurement of masking policies at the school and district level, for its accounting for other factors such as school-level ventilation upgrades, and its consideration of outcomes throughout the 2020/21 school year – reported on the correlation between masking and COVID-19 case rates in Florida, New York, and Massachusetts.[53] In Florida, school mask policies fell into one of three categories: masks required for both staff and students; masks required only for staff; and no masks required. The figure (Figure 4, reproduced exactly from the paper) shows how case rates evolved over the school year (between October 2020 and April 2021) for each of the three groups. Through much of the school year, COVID case rates were lowest among both staff and children for locations that required only staff to mask (top panel). In fact, there were no statistically significant differences in the case rates among the three groups; that is, locations with mask mandates on either staff or students did no better in case rates relative to locations with no mandates (bottom panel). The primary finding for Florida extends to the other states the authors analyzed: mask mandates for students are effectively uncorrelated with COVID-19 infection rates in either students or teachers.

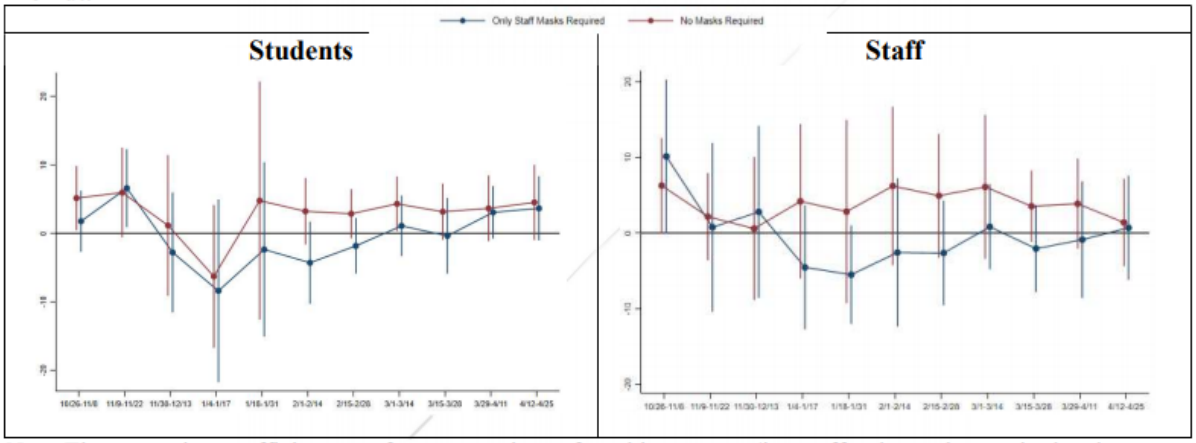
[53] Emily Oster, Rebecca Jack, Clare Halloran, John Schoof, Diana McLeod (2021) "COVID-19 Mitigation Practices and COVID-19 Rates in Schools: Report on Data from Florida, New York and Massachusetts" medRxiv, May 21, 2021, doi: https://doi.org/10.1101/2021.05.19.21257467

Figure 4a. Mean Student and Staff Case Rates by Masking Requirements in Florida



Note. Florida masking practices are categorized into three groups: masks required for both students and staff, masks required for staff only, and no masks required for either students or staff. Case rates are reported as daily COVID-19 case rates per 100,000. Mean daily case rate is calculated by group per biweekly wave in the data. Means do not control for community case rates or population demographics.

Figure 4b. Regression Coefficients of Student and Staff Case Rates on Masking Requirements in Florida



Note. The regression coefficients are from regressions of masking groups (i.e. staff-only masks required and no masks required) interacted with each biweekly wave group on student and staff case rates. The comparison is masks required for both students and staff. Regressions control for community case rates, time fixed effects, racial demographics, density groups, ventilation upgrades, and school level. Regressions are weighted by total student enrollment and standard errors are clustered by school districts.

61. Given the negative evidence from high-quality randomized studies on the efficacy of masking in the context of the flu, the fact that the only two randomized trials on the efficacy of masking in adults both found minimal and statistically insignificant (Danish study) or barely statistically significant (Bangladeshi study) effects of masking on self-protection and source control, that there are no randomized trials in the contexts of masking children in schools, and that there is mixed evidence from observational studies, it is not correct to conclude that masking children in schools has limited the spread of COVID-19. The correct conclusion is that there is no established correlation, and hence no scientific basis for mandating the children be masked.

Harms to children by mask wearing in schools

62. By contrast with the poor-quality evidence that masking children in schools has any effect whatsoever on COVID-19 disease spread, there is ample evidence of some physical and developmental harms to children that accrue from wearing masks.

63. One interesting study compares the hemoglobin content of blood collected from before the pandemic led to lockdown versus blood collected during the pandemic through December 2020. The study analyzes a large sample size of over 19,500 blood donors. The study's basic premise is that if masking creates hypoxia (sometimes experienced as difficulty breathing when masked), then a donor's body will respond by making a larger quantity of hemoglobin to compensate. This is precisely what the researchers observe. They conclude that "prolonged use of face mask by blood donors may lead to intermittent hypoxia and consequent increase in hemoglobin mass." Of course, if this conclusion is true for blood donors, it is likely to be true for school children.

64. A study surveying parents and pediatricians documents that a substantial fraction of children required to wear masks experience immediate physical side-effects, including speaking difficulties, changes in mood, discomfort breathing, headache, and cutaneous disorders (i.e., face rashes). In addition to these physical problems, masking children causes psychological stress in children and disrupts learning.

65. Covering the lower half of the face of both teacher and pupil reduces the ability to communicate. In particular, children lose the experience of mimicking expressions, an essential tool of nonverbal communication. Positive emotions such as laughing and smiling become less recognizable, and negative emotions get amplified. Bonding between teachers and students takes a big hit. Masking exacerbates the chances that a child will

experience anxiety and depression, which are already at pandemic levels themselves. The World Health Organization's guidance document on child masking says that up to age five, masking children may harm the achievement of "childhood developmental milestones." For children between six and eleven, the same document says that mask guidance should consider the "potential impact of mask-wearing on learning and psychosocial development." The WHO explicitly recommends against masks during exercise because masks make breathing more difficult. Another review concludes:

> "[C]overing the lower half of the face reduces the ability to communicate, interpret, and mimic the expressions of those with whom we interact. Positive emotions become less recognizable, and negative emotions are amplified. Emotional mimicry, contagion, and emotionality in general are reduced and (thereby) bonding between teachers and learners, group cohesion, and learning – of which emotions are a major driver."

66. Finally, a perspective piece by the first author of the New England Journal of Medicine piece on the Swedish experience with open schools (cited above) raises the likely possibility that children are less likely to comply with optimal mask wearing protocols than adults. The author's reasoning against the wisdom of masking children is worth quoting in full:

> "Face masks also have potential disadvantages, such as hindering verbal and non-verbal communication. There is a risk that children will keep touching their masks and actually increase the viral load on their hands. Using face masks also risks replacing social distancing, as some parents may be tempted to send their children to school or daycare wearing a mask if they have minor symptoms rather than keeping them at home. Finally, the commercially made masks that are currently available, especially the N95 masks that are said to offer greater protection, rarely fit children. Hence the use of such masks might lead to a false sense of safety, despite leaking viruses due to their poor fit. However, the most important drawback of face masks in children may well be that their use could reduce the focus from other measures that may be more important, such as hand washing, social distancing and staying at home when they are sick."

67. In sum, the harm to children of mask wearing in school outweighs any perceived benefit with respect to reducing the spread of COVID-19.

68. Based on the foregoing, and as iterated above, it is my professional opinion that mask mandates in schools are unnecessary to control mortality and severe disease from the COVID-19 disease. There is no high-quality evidence supporting the proposition that requiring children to wear masks in schools is effective in slowing the community spread of the SARS-CoV-2 virus, which causes COVID-19.

69. I reserve the right to supplement this declaration in writing or through oral testimony up to and through the time of a hearing. Supplementation will include testimony and evidence that expands upon the contents of this affidavit as well as necessary information outside of the four corners of this declaration.

On this _27th day of September, 2021, I, Jay Bhattacharya, pursuant to 28 U.S.C. §1746, declare that I have read the foregoing declaration and the same is true to my own knowledge, except as to matters therein stated to be alleged on information and belief, and as to those matters, I believe them to be true.

/s/ **Jayanta Bhattacharya**

Jayanta Bhattacharya, MD, PhD

EXHIBIT A

JAY BHATTACHARYA, M.D., Ph.D. **September 2021**

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RESEARCH INTERESTS

Health economics, health policy, and outcomes research

A. ACADEMIC HISTORY:

Stanford University	A.M., A.B.	1990
Stanford University School of Medicine	M.D.	1997
Stanford University Department of Economics	Ph.D.	2000

B. EMPLOYMENT HISTORY:

2001 – present	Professor (Assistant to Full), Stanford University Department of Medicine, Department of Economics (by courtesy)
2013 – present	Senior Fellow, Stanford Institute for Economic Policy Research
2014 – present	Senior Fellow Stanford Freeman Spogli Institute
2007 – present	Research Associate, Sphere Institute / Acumen LLC
2002 – present	FRF to Research Associate, National Bureau of Economic Research
2001 – 2020	Professor (Assistant to Full) Department of Health Research and Policy (by courtesy)
2006 – 2008	Research Fellow, Hoover Institution
1998 – 2001	Economist (Associate to Full), RAND Corporation
1998 – 2001	Visiting Assistant Professor, UCLA Department of Economics

C. SCHOLARLY PUBLICATIONS:

PEER-REVIEWED ARTICLES (154 total)

1. Yoshikawa A, Vogt W.B., Hahn J., **Bhattacharya J.**, "Toward the Establishment and Promotion of Health Economics Research in Japan," *Japanese Journal of Health Economics and Policy* 1(1):29-45, (1994).
2. Vogt WB, **Bhattacharya J**, Kupor S, Yoshikawa A, Nakahara T, "The Role of Diagnostic Technology in Competition among Japanese Hospitals," *International Journal of Technology Management, Series on Management of Technology in Health Care*, 11(1):93-105 (1995).
3. **Bhattacharya J**, Vogt WB, Yoshikawa A, Nakahara T, "The Utilization of Outpatient Medical Services in Japan," *Journal of Human Resources*, 31(2): 450-76, (1996).
4. Vogt WB, Kupor S, **Bhattacharya J**, Yoshikwawa A, Nakahara T, "Technology and Staffing in Japanese University Hospitals: Government vs. Private," *International Journal of Technology Assessment in Health Care*, 12(1): 93-103, (1996).

5. Sturm R, Gresenz C, Sherbourne C, **Bhattacharya J**, Farley D, Young AS, Klap R, Minnium K, Burnham MA, and Wells KB. "The Design of Healthcare for Communities: A Study of Health Care Delivery for Alcohol, Drug Abuse, and Mental Health Conditions." *Inquiry* 36(2):221-33 (1999).
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1. **Bhattacharya J**, Garber AM, MaCurdy T. "Cause-Specific Mortality Among Medicare Enrollees," in Inquires in the Economics of Aging, D Wise (ed.), Chicago, IL: University of Chicago Press. (1997).
2. MaCurdy T, Nechyba T, **Bhattacharya J**. "Ch. 2: An Economic Model of the Fiscal Impacts of Immigration," The Immigration Debate: Studies on the Economic, Demographic, and Fiscal Effects of Immigration, J Smith (ed.), National Academy of Sciences Commission on Behavioral and Social Sciences and Education: Washington D.C., (1998).
3. **Bhattacharya J**, Currie J. "Youths and Nutritional Risk: Malnourished or Misnourished?" in Risky Behavior Among Youths, J Gruber (ed.), (2001).
4. Yoshikawa A. and **Bhattacharya J**. "Japanese Health Care" in World Health Systems: Challenges and Perspectives, Bruce Fried and Laura M. Gaydos (eds.), Chicago, IL: Health Administration Press (2002).
5. **Bhattacharya J**, Cutler D, Goldman DP, Hurd MD, Joyce GF, Lakdawalla DN, Panis CWA, and Shang B, "Disability Forecasts and Future Medicare Costs" Frontiers in Health Policy Research, Vol. 6, Alan Garber and David Cutler (eds.) Boston, MA: MIT Press (2003).
6. **Bhattacharya J**, Choudhry K, and Lakdawalla D. (2007) "Chronic Disease and Trends in Severe Disability in Working Age Populations" Proceedings from the Institute of Medicine workshop, 'Disability in America: An Update,' Institute of Medicine: Washington, D.C.
7. **Bhattacharya J**, Garber AM, MaCurdy T. "Trends in Prescription Drug Use by the Disabled Elderly" in Developments in the Economics of Aging, D. Wise (ed), Chicago, IL, University of Chicago Press (2009).
8. **Bhattacharya J** and Richmond P "On Work and Health Among the American Poor" in Pathways to Self-Sufficiency: Getting Ahead in an Era Beyond Welfare Reform John Karl Scholz and Carolyn Heinrich (eds), New York, NY, Russell Sage Foundation (2009).
9. **Bhattacharya J**, Garber A, MaCurdy T "The Narrowing Dispersion of Medicare Expenditures 1997-2005" in Research Findings in the Economics of Aging, D. Wise (ed.), Chicago, IL, University of Chicago Press (2010)
10. **Bhattacharya J**, Bundorf MK, Pace N, and Sood N "Does Health Insurance Make You Fat?" in Economic Aspects of Obesity Michael Grossman and Naci Mocan (eds.), Chicago, IL, University of Chicago Press (2010)
11. **Bhattacharya J**, Garber A, Miller M, and Perlroth D "The Value of Progress against Cancer in the Elderly" Investigations in the Economics of Aging, David Wise (ed), Chicago, IL, University of Chicago Press (2012)
12. Yoshikawa A. and **Bhattacharya J**. "Japanese Health Care" in World Health Systems: Challenges and Perspectives, 2nd edition, Bruce Fried and Laura M. Gaydos (eds.), Chicago, IL: Health Administration Press (2012).
13. Hanson, J., Chandra, A., Moss, E., **Bhattacharya, J.** Wolfe, B., Pollak, S.D.. Brain Development and Poverty: Preliminary Findings. In Biological Consequences of

Socioeconomic Inequalities. B. Wolfe, T. Seeman, and W. Evans (Eds). NY: Sage. (2012)

14. **Bhattacharya J** "The Diffusion of New Medical Technologies: The Case of Drug-Eluting Stents (A Discussion of Chandra, Malenka, and Skinner)" In Explorations in the Economics of Aging, David Wise (ed.), Chicago, IL, University of Chicago Press (2014).
15. MaCurdy T and **Bhattacharya J** "Challenges in Controlling Medicare Spending: Treating Highly Complex Patients" in Insights in the Economics of Aging, David Wise (ed.) Chicago, IL, University of Chicago Press (2015).

ABSTRACTS (3)

1. Su CK and **Bhattacharya J**. Longitudinal Hospitalization Costs and Outcomes in the Treatment of the Medicare Breast Cancer Patient. *International Journal of Radiation Oncology Biology Physics* (1996); 36(S1): 282. [abstract]
2. Nguyen C, Hernandez-Boussard T., Davies S, **Bhattacharya J**, Khosla R, Curtin C. *Cleft Palate Surgery: Variables of Quality and Patient Safety*. Presented at the 69th Annual American Cleft-Palate Craniofacial Association (2012). [abstract]
3. Patel MI, Ramirez D, Agajanian R, Bhattacharya J, Milstein A, Bundorf MK. "The effect of a lay health worker-led symptom assessment intervention for patients on patient-reported outcomes, healthcare use, and total costs." Journal of Clinical Oncology 36(15 Suppl):6502 [abstract]

D. PUBLIC AND PROFESSIONAL SERVICE:

JOURNAL EDITING

Journal of Human Capital, Associate Editor (2015-present)
American Journal of Managed Care, Guest Editor (2016)
Journal of Human Resources, Associate Editor (2011-13)
Forum for Health Economics & Policy, Editorial Board Member (2001-2012)
Economics Bulletin, Associate Editor (2004-2009)

SERVICE ON SCIENTIFIC REVIEW AND ADVISORY COMMITTEES (Selected)

- Standing member of the Health Services Organization and Delivery (HSOD) NIH review panel, 2012-2016
- NIH reviewer (various panels, too numerous to list) 2003-present
- NIH Review Panel Chair: 2018 (P01 review), 2020 (DP1 review).
- Invited Reviewer for the European Research Council, ERC Advanced Grant 2015 RFP
- NIH Stage 2 Challenge Grant Review Panel, July 2009
- Appointed a member of an Institute of Medicine (IOM) panel on the regulation of work hours by resident physicians, 2007-8.
- Standing member of the NIH Social Science and Population Studies Review Panel, Fall 2004-Fall 2008

- Invited Reviewer for National Academy of Sciences report on Food Insecurity and Hunger, November 2005.
- Invited Reviewer for the National Academy of Sciences report on the Nutrition Data Infrastructure, December 2004
- Invited Reviewer for the National Institute on Health (NIH) Health Services Organization and Delivery Review Panel, June 2004, Alexandria, VA.
- Invited Reviewer for the Food Assistance and Nutrition Research Program US Department of Agriculture Economic Research Service Research Proposal Review Panel, June 2004, Stanford, CA.
- Invited Reviewer for the National Institute on Health (NIH) Social Science and Population Studies Review Panel, February 2004, Alexandria, VA.
- Invited Reviewer for the National Institute on Health (NIH) Social Sciences and Population Studies Review Panel, November 2003, Bethesda, MD.
- Invited Reviewer for the National Institute on Health (NIH) Social Science, Nursing, Epidemiology, and Methods (3) Review Panel, June 2003, Bethesda, MD.
- Invited Reviewer for the Food Assistance and Nutrition Research Program US Department of Agriculture Economic Research Service Research Proposal Review Panel, August 2002.
- Research Advisory Panel on Canadian Disability Measurement, Canadian Human Resources Development Applied Research Branch, June 2001 in Ottowa, Canada.
- Invited Reviewer for the National Institute of Occupational Safety and Health R18 Demonstration Project Grants Review panel in July 2000, Washington D.C.
- Research Advisory Panel on Japanese Health Policy Research. May 1997 at the Center for Global Partnership, New York, NY.

TESTIMONY TO GOVERNMENTAL PANELS AND AGENCIES (9)

- US Senate Dec. 2020 hearing of the Subcommittee on Homeland Security and Governmental Affairs. Testimony provided on COVID-19 mortality risk, collateral harms from lockdown policies, and the incentives of private corporations and the government to invest in research on low-cost treatments for COVID-19 disease
- "Roundtable on Safe Reopening of Florida" led by Florida Gov. Ron DeSantis. September 2020.
- "Evaluation of the Safety and Efficacy of COVID-19 Vaccine Candidates" July 2020 hearing of the House Oversight Briefing to the Economic and Consumer Policy Subcommittee.
- US Senate May 2020 virtual roundtable. Safely Restarting Youth Baseball and Softball Leagues, invited testimony
- "Population Aging and Financing Long Term Care in Japan" March 2013 seminar at the Japanese Ministry of Health.
- "Implementing the ACA in California" March 2011 testimony to California Legislature Select Committee on Health Care Costs.
- "Designing an Optimal Data Infrastructure for Nutrition Research" June 2004 testimony to the National Academy of Sciences commission on "Enhancing the Data Infrastructure

in Support of Food and Nutrition Programs, Research, and Decision Making," Washington D.C.

- "Measuring the Effect of Overtime Reform" October 1998 testimony to the California Assembly Select Committee on the Middle Class, Los Angeles, CA.
- "Switching to Weekly Overtime in California." April 1997 testimony to the California Industrial Welfare Commission, Los Angeles, CA.

REFEREE FOR RESEARCH JOURNALS

American Economic Review; American Journal of Health Promotion; American Journal of Managed Care; Education Next; Health Economics Letters; Health Services Research; Health Services and Outcomes Research Methodology; Industrial and Labor Relations Review; Journal of Agricultural Economics; Journal of the American Medical Association; Journal of Health Economics; Journal of Health Policy, Politics, and Law; Journal of Human Resources; Journal of Political Economy; Labour Economics; Medical Care; Medical Decision Making; Review of Economics and Statistics; Scandinavian Journal of Economics; Social Science and Medicine; Forum for Health Economics and Policy; Pediatrics; British Medical Journal

Trainee	**Current Position**
Peter Groeneveld, MD, MS	Associate Professor of Medicine, University of Pennsylvania
Jessica Haberer, MD, MS	Assistant Professor of Medicine, Harvard Medical School
Melinda Henne, MD, MS	Director of Health Services Research, Bethesda Naval Hospital
Byung-Kwang Yoo, MD, PhD	Associate Professor, Public Health, UC Davis
Hau Liu, MD, MS, MBA	Chief Medical Officer at Shanghai United Family Hospital
Eran Bendavid, MD, MS	Assistant Professor, General Medicine Disciplines, Stanford University
Kaleb Michaud, MS, PhD	Associate Professor of Medicine, Rheumatology and Immunology, University of Nebraska Medical Center
Kanaka Shetty, MD	Natural Scientist, RAND Corporation
Christine Pal Chee, PhD	Associate Director of the Health Economics Resource Center, Palo Alto VA
Matthew Miller, MD	VP Clinical Strategy and Head of Innovation, Landmark Health
Vincent Liu, MD	Research Scientist, Kaiser Permanente Northern California Division of Research
Daniella Perlroth, MD	Chief Data Scientist, Lyra Health
Crystal Smith-Spangler, MD	Internist, Palo Alto Medical Foundation
Barrett Levesque, MD MS	Assistant Professor of Clinical Medicine, UC San Diego Health System
Torrey Simons, MD	Clinical Instructor, Department of Medicine, Stanford University
Nayer Khazeni, MD	Assistant Professor of Medicine (Pulmonary and Critical Care Medicine), Stanford University
Monica Bhargava, MD MS	Assistant Clinical Professor, UCSF School of Medicineilan
Dhruv Kazi, MD	Assistant Professor, UCSF School of Medicine
Zach Kastenberg, MD	Resident, Department of Surgery, Stanford University
Kit Delgado, MD	Assistant Professor, Department of Emergency Medicine and Faculty Fellow, University of Pennsylvania
Suzann Pershing, MD	Chief of Ophtalmology for the VA Palo Alto Health Care System
KT Park, MD	Assistant Professor, Department of Medicine, Stanford University
Jeremy Goldhaber-Fiebert, PhD	Associate Professor, Department of Medicine, Stanford University
Sanjay Basu, MD	Assistant Professor, Department of Medicine, Stanford University
Marcella Alsan, MD, PhD	Assistant Professor, Department of Medicine (CHP/PCOR), Stanford Univ.
David Chan, MD, PhD	Assistant Professor, Department of Medicine (CHP/PCOR), Stanford Univ.
Karen Eggleston, PhD	Senior Fellow, Freeman Spogli Institute, Stanford University
Kevin Erickson, MD	Assistant Professor, Department of Nephrology, Baylor College of Medicine
Ilana Richman, MD	VA Fellow at CHP/PCOR, Stanford University

Alexander Sandhu, MD	VA Fellow at CHP/PCOR, Stanford University
Michael Hurley	Medical Student, Stanford University
Manali Patel, MD	Instructor, Department of Medicine (Oncology), Stanford University
Dan Austin, MD	Resident Physician, Department of Anesthesia, UCSF School of Medicine
Anna Luan, MD	Resident Physician, Department of Medicine, Stanford University
Louse Wang	Medical Student, Stanford University
Christine Nguyen, MD	Resident Physician, Department of Medicine, Harvard Medical School
Josh Mooney, MD	Instructor, Department of Medicine (Pulmonary and Critical Care Medicine), Stanford University
Eugene Lin, MD	Fellow, Department of Medicine (Nephrology), Stanford University
Eric Sun, MD	Assistant Professor, Department of Anesthesia, Stanford University
Sejal Hathi	Medical Student, Stanford University
Ibrahim Hakim	Medical Student, Stanford University
Archana Nair	Medical Student, Stanford University
Trishna Narula	Medical Student, Stanford University
Daniel Vail	Medical Student, Stanford University
Tej Azad	Medical Student, Stanford University
Jessica Yu, MD	Fellow, Department of Medicine (Gastroenterology), Stanford University
Daniel Vail	Medical Student, Stanford University
Alex Sandhu, MD	Fellow, Department of Medicine (Cardiology), Stanford University
Matthew Muffly, MD	Clinical Assistant Professor, Dept. of Anesthesia, Stanford University

Dissertation Committee Memberships

Ron Borzekowski	Ph.D. in Economics	Stanford University	2002
Jason Brown	Ph.D. in Economics	Stanford University	2002
Dana Rapaport	Ph.D. in Economics	Stanford University	2003
Ed Johnson	Ph.D. in Economics	Stanford University	2003
Joanna Campbell	Ph.D. in Economics	Stanford University	2003
Neeraj Sood*	Ph.D. in Public Policy	RAND Graduate School	2003
James Pearce	Ph.D. in Economics	Stanford University	2004
Mikko Packalen	Ph.D. in Economics	Stanford University	2005
Kaleb Michaud*	Ph.D. in Physics	Stanford University	2006
Kyna Fong	Ph.D. in Economics	Stanford University	2007
Natalie Chun	Ph.D. in Economics	Stanford University	2008
Sriniketh Nagavarapu	Ph.D in Economics	Stanford University	2008
Sean Young	Ph.D. in Psychology	Stanford University	2008
Andrew Jaciw	Ph.D. in Education	Stanford University	2010
Chirag Patel	Ph.D. in Bioinformatics	Stanford University	2010
Raphael Godefroy	Ph.D. in Economics	Stanford University	2010
Neal Mahoney	Ph.D. in Economics	Stanford University	2011
Alex Wong	Ph.D. in Economics	Stanford University	2012
Kelvin Tan	Ph.D. in Management Science	Stanford University	2012
Animesh Mukherjee	Masters in Liberal Arts Program	Stanford University	2012
Jeanne Hurley	Masters in Liberal Arts Program	Stanford University	2012
Patricia Foo	Ph.D. in Economics	Stanford University	2013
Michael Dworsky	Ph.D. in Economics	Stanford University	2013
Allison Holliday King	Masters in Liberal Arts Program	Stanford University	2013
Vilsa Curto	Ph.D. in Economics	Stanford University	2015
Rita Hamad	Ph.D. in Epidemiology	Stanford University	2016
Atul Gupta	Ph.D. in Economics	Stanford University	2017
Yiwei Chen	Ph.D. in Economics	Stanford University	2019
Yiqun Chen	Ph.D. in Health Policy	Stanford University	2020
Min Kim	Ph.D. in Economics	Iowa State Univ.	2021
Bryan Tysinger	Ph.D. in Public Policy	RAND Graduate School	2021

E. GRANTS AND PATENTS

PATENT (2)

1. "Environmental Biomarkers for the Diagnosis and Prognosis for Type 2 Diabetes Mellitus" with Atul Butte and Chirag Patel (2011), US Patent (pending).
2. "Health Cost and Flexible Spending Account Calculator" with Schoenbaum M, Spranca M, and Sood N (2008), U.S. Patent No. 7,426,474.

GRANTS AND SUBCONTRACTS (42)

CURRENT (6)

2019-2020	Funder: Acumen, LLC. Title: Quality Reporting Program Support for the Long-Term Care Hospital, Inpatient Rehabilitation Facility, Skilled Nursing Facility QRPs and Nursing Home Compare Role: PI
2018-2020	Funder: Acumen, LLC. Title: Surveillance Activities of Biologics Role: PI
2018-2020	Funder: France-Stanford Center for Interdisciplinary Studies Title: A Nutritional Account of Global Trade: Determinants and Health Implications Role: PI
2017-2023	Funder: National Institutes of Health Title: The Epidemiology and Economics of Chronic Back Pain Role: Investigator (PI: Sun)
2017-2021	Funder: National Institutes of Health Title: Big Data Analysis of HIV Risk and Epidemiology in Sub-Saharan Africa Role: Investigator (PI: Bendavid)
2016-2020	Funder: Acumen, LLC. Title: MACRA Episode Groups and Resource Use Measures II Role: PI

PREVIOUS (36)

2016-2018	Funder: University of Kentucky Title: Food acquisition and health outcomes among new SNAP recipients since the Great Recession Role: PI
2015-2019	Funder: Alfred P. Sloan Foundation

	Title: Public versus Private Provision of Health Insurance Role: PI
2015-2019	Funder: Natural Science Foundation Title: Health Insurance Competition and Healthcare Costs Role: Investigator (PI: Levin)
2014-2015	Funder: The Centers for Medicare and Medicaid Services Title: Effect of Social Isolation and Loneliness on Healthcare Utilization Role: PI
2014-2015	Funder: AARP Title: The Effect of Social Isolation and Loneliness on Healthcare Utilization and Spending among Medicare Beneficiaries Role: PI
2013-2019	Funder: National Bureau of Economic Research Title: Innovations in an Aging Society Role: PI
2013-2014	Funder: Robert Wood Johnson Foundation Title: Improving Health eating among Children through Changes in Supplemental Nutrition Assistance Program (SNAP) Role: Investigator (PI: Basu)
2011-2016	Funder: National Institutes of Health (R37) Title: Estimating the Potential Medicare Savings from Comparative Effectiveness Research Role: PI Subaward (PI: Garber)
2011-2016	Funder: National Institute of Aging (P01) Title: Improving Health and Health Care for Minority and Aging Populations Role: PI Subcontract (PI: Wise)

2010-2018	Funder: National Institutes of Health Title: Clinic, Family & Community Collaboration to Treat Overweight and Obese Children Role: Investigator (PI: Robinson)
2010-2014	Funder: Agency for Health, Research and Quality (R01) Title: The Effects of Private Health Insurance in Publicly Funded Programs Role: Investigator (PI: Bundorf)
2010-2013	Funder: Agency for Healthcare Research and Quality Title: G-code" Reimbursement and Outcomes in Hemodialysis Role: Investigator (PI: Erickson)
2010-2013	Funder: University of Southern California Title: The California Medicare Research and Policy Center Role: PI
2010-2012	Funder: University of Georgia Title: Natural Experiments and RCT Generalizability: The Woman's Health Initiative Role: PI
2010-2011	Funder: National Bureau of Economic Research Title: Racial Disparities in Health Care and Health Among the Elderly Role: PI
2009-2020	Funder: National Institute of Aging (P30) Title: Center on the Demography and Economics of Health and Aging Role: PI (2011-2020)
2009-2011	Funder: Rand Corporation Title: Natural Experiments and RCT Generalizability: The Woman's Health Initiative Role: PI
2008-2013	Funder: American Heart Association Title: AHA-PRT Outcomes Research Center Role: Investigator (PI: Hlatky)
2007-2009	Funder: National Institute of Aging (R01) Title: The Economics of Obesity Role: PI
2007-2009	Funder: Veterans Administration, Health Services Research and Development Service Title: Quality of Practices for Lung Cancer Diagnosis and Staging Role: Investigator
2007-2008	Funder: Stanford Center for Demography and Economics of Health and Aging Title: The HIV Epidemic in Africa and the Orphaned Elderly

	Role: PI
2007	Funder: University of Southern California Title: The Changes in Health Care Financing and Organization Initiative Role: PI
2006-2010	Funder: National Institute of Aging (K02) Title: Health Insurance Provision for Vulnerable Populations Role: PI
2006-2010	Funder: Columbia University/Yale University Title: Dummy Endogenous Variables in Threshold Crossing Models, with Applications to Health Economics Role: PI
2006-2007	Funder: Stanford Center for Demography and Economics of Health and Aging Title: Obesity, Wages, and Health Insurance Role: PI
2005-2009	Funder: National Institute of Aging (P01 Subproject) Title: Medical Care for the Disabled Elderly Role: Investigator (PI: Garber)
2005-2008	Funder: National Institute of Aging (R01) Title: Whom Does Medicare Benefit? Role: PI Subcontract (PI: Lakdawalla)
2002	Funder: Stanford Center for Demography and Economics of Health and Aging Title: Explaining Changes in Disability Prevalence Among Younger and Older American Populations Role: PI
2001-2003	Funder: Agency for Healthcare Research and Quality (R01) Title: State and Federal Policy and Outcomes for HIV+ Adults Role: PI Subcontract (PI: Goldman)
2001-2002	Funder: National Institute of Aging (R03) Title: The Economics of Viatical Settlements Role: PI
2001-2002	Funder: Robert Woods Johnson Foundation Title: The Effects of Medicare Eligibility on Participation in Social Security Disability Insurance Role: PI Subcontract (PI: Schoenbaum)
2001-2002	Funder: USDA Title: Evaluating the Impact of School Breakfast and Lunch Role: Investigator
2001-2002	Funder: Northwestern/Univ. of Chicago Joint Center on Poverty Title: The Allocation of Nutrition with Poor American Families Role: PI Subcontract (PI: Haider)
2000-2002	Funder: National Institute on Alcohol Abuse & Alcoholism (R03) Title: The Demand for Alcohol Treatment Services Role: PI
2000-2001	Funder: USDA Title: How Should We Measure Hunger?

Role: PI Subcontract (PI: Haider)

F. SCHOLARSHIPS AND HONORS

- Phi Beta Kappa Honor Society, 1988
- Distinction and Departmental Honors in Economics, Stanford University, 1990
- Michael Forman Fellowship in Economics, Stanford University, 1991-1992
- Agency for Health Care Policy and Research Fellowship 1993-1995
- Outstanding Teaching Assistant Award, Stanford University, Economics, 1994
- Center for Economic Policy Research, Olin Dissertation Fellowship, 1997-1998
- Distinguished Award for Exceptional Contributions to Education in Medicine, Stanford University, 2005, 2007, and 2013.
- Dennis Aigner Award for the best applied paper published in the *Journal of Econometrics*, 2013